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METHODOLOGY INVESTIGATION. INTENSIVE TROPIC FUNCTION TESTING.(U)

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TECOM PROJECT NO. 7-CO-RDT-TT1-001

USATTC REPORT NO. 781103

LEVEL II

METHODOLOGY INVESTIGATION

FINAL REPORT

INTENSIVE TROPIC FUNCTION TESTING

By

Eldon M. Cady, Jr.
Robert J. Gorak

November 1978

Approved for public release, distribution unlimited.

UNITED STATES ARMY TROPIC TEST CENTER
APO MIAMI 34004

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

USATTC conducted a methodology investigation in the humid tropics of the Canal Zone from March 1976 through March 1977. The objective was to determine whether intensive function testing or simulated tactical function testing can produce tropic-related effects similar to effects found after storage, while reducing the length of time typically required for tropic storage test designs. The US Army's 1.5-kilowatt AC generator was selected to evaluate three alternative test designs to determine whether one or more designs would accelerate

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tropic materiel defects and thereby shorten test time. The test designs were: intensive functioning, simulated tactical use and storage. The last is the prevailing design used by USATTC in tropic tests. RAM data were collected on five generators in each of the three design groups.

It was concluded that: (1) The intensive functioning test design was less severe than either the storage or simulated tactical use test designs, (2) More valid RAM estimates can be obtained in the tropics when test designs incorporate expected field use patterns, (3) The generators of the storage test design exhibited no tropic storage-related effects; therefore, no conclusion could be drawn concerning the equivalence of the test designs in producing tropic storage-related effects.

TABLE OF CONTENTS

FOREWORD ii

SECTION 1. SUMMARY

1.1 BACKGROUND 1

1.2 OBJECTIVE 1

1.3 SUMMARY OF PRODECURES 1

1.4 SUMMARY OF RESULTS 2

1.5 ANALYSIS 2

1.6 CONCLUSIONS 3

1.7 RECOMMENDATIONS 3

SECTION 2. DETAILS OF INVESTIGATION

2.1 MATERIALS AND METHODS 5

2.2 RESULTS AND ANALYSIS 8

SECTION 3. APPENDIXES

A TEST DIRECTIVES AND METHODOLOGY INVESTIGATION PROPOSAL A-1

B REFERENCES B-1

C DISTRIBUTION LIST C-1

FOREWORD

This work was initiated by J. C. Bryan, former Operations Research Analyst, US Army Tropic Test Center. Mr. Bryan was responsible for the basic test design. David Morrison, Mathematical Statistician, US Army Tropic Test Center, assisted in RAM analyses.

The project was conceived by and conducted under the technical supervision of Dr. D. A. Dobbins, former Chief, Technical Division, US Army Tropic Test Center; and completed under Adam A. Rula, Chief, Materiel Test Division.

SECTION 1. SUMMARY

1.1 BACKGROUND

A continuing goal of the Army Research, Development, Test and Evaluation (RDTE) community is to shorten the materiel acquisition process without sacrificing materiel quality.[1] It was hypothesized that reducing test calendar time while increasing equipment functioning time would yield valid tropic reliability and maintainability results for some categories of equipment.

Army materiel deployed in the tropics normally undergoes some period of storage; therefore, tropic tests have traditionally included a storage phase. Because the storage period represents a significant amount of calendar time, it has been proposed that the storage phase be shortened or eliminated and items be tested at an intensive functioning rate. The US Army Tropic Test Center (USATTC) has observed materiel failures immediately following tropic storage. Because of this and because information is often desired in less time than tropic storage tests take to complete, a methodology investigation was conducted to determine if equivalent but accelerated results could be obtained without storage.

1.2 OBJECTIVE

Determine if intensive function testing or simulated tactical function testing can produce tropic-related effects similar to effects found after storage in less time than is required for tropic storage test designs.

1.3 SUMMARY OF PROCEDURES

Fifteen 1.5-kilowatt AC generators were separated into three groups of five generators each, in order that each group could be functioned on a different schedule. The Intensive Function Mode group was operated at a rate of 16 hours per day for 6 months; the Storage Mode Group was operated at a rate of 4 hours per day for 100 operational hours, placed in storage at the test site for 6 months and returned to operation at the same operational rate for the remainder of the year; the Simulated Tactical Use Mode group was functioned at a rate of 4 hours per day for 1 year. The test site selected was a concrete pad in the Fort Clayton General Purpose Test Area in the humid tropics of the Canal Zone. The power produced by each generator was consumed by a series of 300-watt light bulbs. Every hour the operator varied the power load from 900 to 1500 watts for a 15-second period. Hourly records were kept of the stable voltage and frequency levels and the total amount of operational time elapsed. Changes in the normal operational behavior of a generator were used as indicators of a malfunction

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[1] AR 1000-1, Basic Policy for Systems Acquisition, 1 April 1978.

and repairs were performed by USATTC maintenance personnel. Reliability, Availability and Maintainability (RAM) data were generated from reports made for each maintenance action and from the operator's log book.

1.4 SUMMARY OF RESULTS

Demonstrated mean-time-between-failures (MTBF) of the generators operated in the three test design modes of the study were as follows: Intensive Function Mode, 243.0 hours; Storage Mode, 137.4 hours; Simulated Tactical Use Mode, 139.5 hours. The MTBF of the generators operated in the Intensive Function Mode was approximately double that demonstrated by the generators operated in the Storage and Simulated Tactical Use Modes. This difference is statistically significant at the 0.05 level under the assumption that the number of failures occurring within a specified time is poisson distributed.

Demonstrated mean-time-to-repairs (MTTR) of the generators were as follows: Intensive Function Mode, 0.7 hours; Storage Mode, 1.2 hours; Simulated Tactical Use Mode, 1.2 hours. The MTTRs of the generators of the Storage and Simulated Tactical Use Modes were almost double that for the generators operated in the Intensive Function Mode. This difference is statistically significant at the 0.05 level.

Examination of unscheduled maintenance actions showed that similar types of malfunctions occurred in all three test design modes. A statistical test (at a significance level of 0.05) of the distributions of the types of malfunctions indicated that the distributions did not differ among the three test design modes. Further analysis of the malfunctions of individual components of the generators showed that there were no significant differences in the MTBFs and MTTRs of individual components of the generators among the three test design modes.

Inspection of the Storage Mode generators after 6 months of humid tropic storage revealed no significant visible deterioration of the generators. No significant degradation in performance was observed for these generators during poststorage operation as compared with the prestorage operational performance.

1.5 ANALYSIS

Poststorage inspection of the Storage Mode generators and a comparison of poststorage performance with prestorage performance indicate that no significant degradation had occurred as a result of the 6-month tropic storage. This statement is supported by the similarity of the reliability and maintainability data collected from the generators operated in the Simulated Tactical Use Mode and Storage Mode. These test design modes were identical except for a 6-month period when generators of the Storage Mode were placed into storage, while generators of the Simulated Tactical Use Mode continued to operate at 4 hours per workday. Therefore, generators of these two modes would be expected to demonstrate similar RAM characteristics if the 6 months of tropic storage had no significantly detrimental effect on the generators.

The significantly lower MTTR and higher MTBF of the generators of the Intensive Function Mode indicate that the Intensive Function Mode is less severe than the Storage and Simulated Tactical Use Modes. This result suggests that use conditions play a significant role in determining the RAM characteristics of materiel deployed in the humid tropics.

Analysis of the MTTRs and MTBFs of individual components of the generators indicates that no one component can be singled out as being a primary contributor to the significantly different MTTR and MTBF of the generators of the Intensive Function Mode. Analysis of the distribution of the types of generator malfunctions occurring during the study showed that the distribution of the types of malfunctions occurring in the Intensive Function Mode did not differ fr n those of the other modes. These analyses suggest the tentative hypothesis that the differences in the RAM parameters demonstrated by the generators of the Intensive Function Mode are due to operational and environmental stresses which are of similar nature but of different levels.

1.6 CONCLUSIONS

The intensified functioning mode of materiel testing did not challenge the 1.5-kilowatt alternating current (AC) generators to the same degree as the other test design modes which simulated actual tactical use in the humid tropics. Generators employed in the Intensive Function Mode demonstrated significantly better RAM characteristics than the generators employed in the other modes.

Use conditions and the mode of operation of electromechanical equipment play a significant role in determining the RAM characteristics of materiel deployed in the humid tropics. Employment of developmental test mission profiles which do not parallel expected field use will increase the risk of obtaining estimates of RAM parameters which may be significantly different from those that will be demonstrated under actual field use.

Since no discernable degradation of generator performance was evident after 6 months of tropic storage, no conclusion can be drawn as to whether the Simulated Tactical Use Mode will produce the same or similar tropic-related effects as tropic storage for items that will deteriorate when stored in a dormant state for an extended period of time in a humid tropic environment.

1.7 RECOMMENDATIONS

The intensified functioning mode of materiel testing should not be used in developmental tests of electromechanical materiel in the humid tropics.

Mission profiles employed during tropic developmental tests should parallel those that are expected under actual field-use conditions in the humid tropics.

SECTION 2. DETAILS OF INVESTIGATION

2.1 MATERIALS AND METHODS

An open exposure site was selected at the Fort Clayton General Purpose Test Area (Chiva Chiva) to conduct the intensive tropic function test. This site consisted of a concrete pad area with a shelter for protection of instrumentation and personnel (figure 1). The area was surrounded by high grass with jungle vegetation about 100 meters away.

The purpose of the project was not to test a particular item, but rather to test alternative tropic test designs. The 1.5-kilowatt AC generator was chosen as the test item because it represented a typical electromechanical system, generated sufficient reliability and maintainability data for analysis, and was easy to operate and maintain.

Fifteen of the 1.5-kilowatt generators were obtained. These generators were bolted into place with a 1-inch thick wood spacer between the frame and the concrete pad. This wood spacer acted as a vibration absorber. The final configuration is shown in figure 2.

Fuel was supplied to each generator from a central distribution system designed to provide each generating unit the same quality of fuel. Each generator was isolated from its neighboring generator by a wall of concrete blocks which also served as a fire break. Generator load was supplied by a set of five 300-watt light bulbs designed to provide load levels of 0, 600, 900 and 1500 watts.

Figure 3 shows the separation of the 15 generators into three groups. Each group of five generators was functioned on a different schedule. The generators in the Intensive Function Mode were functioned for 16 hours a day. The generators in the Simulated Tactical Use Mode were operated 4 hours a day. The generators in the Storage Mode were functioned for 4 hours a day until 100 hours of operating time were accumulated, then placed in temporary field storage for 6 months before being returned to the operational cycle at the same operational rate. Generators in all three groups were not operated on weekends or holidays. Temporary field storage conditions are shown in figure 4 with the generator sealed and covered.

On 8 March 1976, the operational phase of the project started with all 15 generators functioning in accordance with their specified operational schedule. That is, there were three groups of five generators functioning on different schedules--Intensive Function, Simulated Tactical Use, and Storage Modes. By 9 April 1976, approximately 100 operational hours had been accumulated on the Storage Mode generators, and those generators were placed into temporary field storage (figure 4). Six months later, 14 October 1976, the storage mode generators were removed from their storage condition and returned to operational status. Those generators continued to function until the end of testing on 9 March 1977.

Figure 1. Aerial View of Test Site.

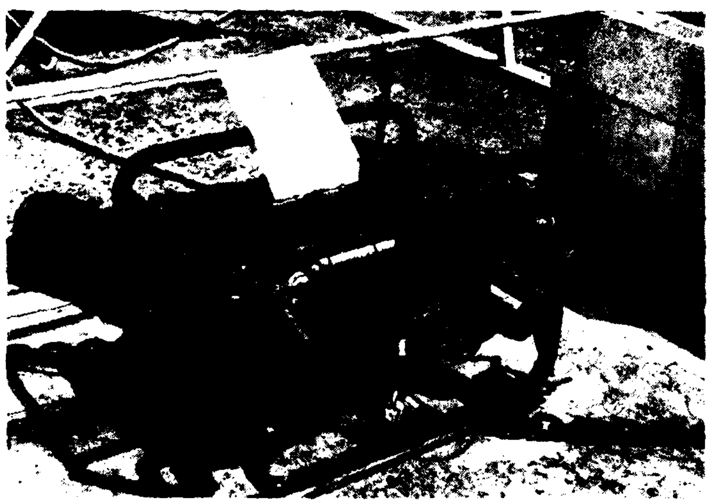

Figure 2. 1.5-KW Generator Mounting Configuration.

Figure 3. Test Site with Generators Mounted on Concrete Pad.

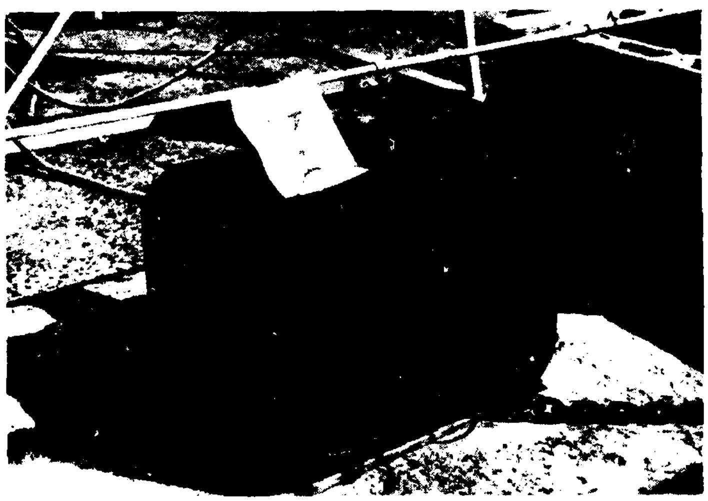

Figure 4. 1.5-KW AC Generator during Tropic Storage.

The Intensive Function Mode generators had no major failures aside from voltage regulator failures until July 1976, when one of the units ceased to produce an output voltage. Inspection of the generator showed that armature wiring had broken from excessive wear attributable to a misalignment of the armature, which probably occurred before the generators were put into operation. No tropic related effects could be identified as causing or contributing to this failure. By 1 October 1976, the four remaining generators were removed from operation after having been functioned on a 16-hour-per-day basis for nearly 6 months without a single major failure that could not be quickly corrected by the operator or maintenance personnel.

The Simulated Tactical Use generators operated 4 hours a day without interruption from the beginning (8 March 1976) to the end (9 March 1977) of testing.

A central control panel displayed each generator's voltage, frequency and accumulated operational time. For any single work period, only one operator was required for operation and basic maintenance of the 15 generators. Every hour, the operator recorded voltage output, elapsed time, frequency, and indicated stability of the voltage and frequency. In addition, loads were cycled from 900 watts to 1500 watts for a 15-second duration once hourly to simulate sudden load changes. The operator was required to perform minor maintenance on the generators in the form of visual inspections for loose connections, tightening of loose fittings and mountings, and changing of oil in each generator approximately every 50 hours of operation as described in the maintenance manual.[2]

2.2 RESULTS AND ANALYSIS

The primary intent of this project was to do a RAM data analysis of the generators as they were functioned in the three test design modes (i.e., Intensive Function, Storage, and Simulated Tactical Use). Maintenance data from DA 2407 forms and operator log books were recorded on standard RAM data collection forms. At the end of the test, a comparison of the three functional modes was performed based upon the RAM parameters.

The RAM data are summarized in tables 1, 2 and 3. RAM parameters selected to assess the severity of the different modes were MTBF and MTTR. These parameters are derived from failure data and unscheduled maintenance data. They are considered primary measures of test mode severity because frequency of failure and the time to repair a failure should increase in proportion to the difficulty of the test mode.

[2] DA Technical Manual, TM-5-6115-323-15, Generator Set, Gasoline Engine Driven, Skid Mounted, Tubular Frame, 1.5 KW, Single Phase, AC, 120/240V, 9 September 1970.

Table 1. Summary of Intensive Function Mode Data

Generator Number	Total Test Hours (A)	Number[1] Maint Actions	Number[2] Chargeable System Failures (B)	Total Corrective Maint Time (hrs) (C)	MTBF (hrs) (A/B)	MTTR (hrs) (C/B)	Active Maintenance Time[1]		
							Unscheduled (man-hrs) (E)	Scheduled (man-hrs) (F)	Total (man-hrs) (E + F)
1	878.6	6	4	3.6	219.7	0.9	3.6	3.0	6.6
2	2033.0	18	10	5.9	203.3	0.6	5.9	6.1	12.0
3	1867.5	17	10	5.7	186.8	0.6	5.7	6.1	11.8
4	2077.9	10	4	3.4	519.5	0.9	3.4	5.1	8.5
5	2133.1	16	9	6.7	237.0	0.7	6.7	4.6	11.3
Total	8990.1	67.0	37.0	25.3			25.3	24.9	50.2
Mean	1798.0	13.4	7.4	5.1	243.0	0.7	5.1	5.0	10.0
Std Dev[3]	523.4	5.2	3.1	1.5			1.5	1.3	2.4

Table 2. Summary of Storage Mode Data

6	502.4	10	4	3.0	125.6	0.8	3.0	8.0	11.0
7	501.3	7	1	1.5	501.3	1.5	1.5	8.0	9.5
8	464.4	14	7	12.9	66.3	1.8	12.9	8.0	20.9
9	502.7	10	4	2.8	125.7	0.7	2.8	8.1	10.9
10	501.5	9	2	1.4	250.8	0.7	1.4	7.6	9.0
Total	2472.3	50.0	18.0	21.6			21.6	39.7	61.3
Mean	494.5	10.0	3.6	4.3	137.4	1.2	4.3	7.9	12.3
Std Dev[3]	16.8	2.5	2.3	4.9			4.9	0.2	4.9

Table 3. Summary of Simulated Tactical Use Mode Data

11	1024.1	6	2	1.3	512.1	0.7	1.3	2.1	3.4
12	978.2	13	8	13.2	122.3	1.7	13.2	3.0	16.2
13	732.3	17	12	16.4	61.0	1.4	16.4	3.5	19.9
14	1004.0	14	8	6.5	125.5	0.8	6.5	4.0	10.5
15	1002.8	8	4	3.7	250.5	0.9	3.7	3.5	7.2
Total	4741.4	58.0	34.0	41.1			41.1	16.1	57.2
Mean	948.3	11.6	6.8	8.2	139.5	1.2	8.2	3.2	11.4
Std Dev[3]	121.8	4.5	3.9	6.4			6.4	0.7	6.7

[1] Excludes oil changes.
[2] All unscheduled maintenance actions were chargeable failures.
[3] Std Dev = Standard Deviation

Other RAM parameters that are derived from scheduled maintenance data, such as Mean Time Between Maintenance (MTBM) and the Number of Maintenance Actions per 1,000 Hours, could not be used for assessment of test mode severity for two reasons. First, all the generators were maintained according to the same schedule and same maintenance procedures as given in the maintenance manual; second, each of the storage mode generators had two additional scheduled maintenance actions directly related to storage operations.

2.2.1 Assumptions

Statistical analyses of the failure data were undertaken with the following assumptions:

a. The number of generator failures occurring within a specified time interval is poisson distributed.

b. The arithmetic mean of the inherent MTBFs of the generators operated in the Storage Mode is nearly identical to that of the generators of the other two test design modes when the generators are operated under identical environmental and operating conditions.

The first assumption was tested by Goodness-of-Fit tests using the Chi-Square statistic at a significance level of 0.05. The tests indicated that the assumption was plausible for the failure data of each test design mode. The second assumption could not be tested because no baseline reliability data were available for an estimate of the inherent population variance.

2.2.2 Analysis of Generator RAM Data by Test Mode

To evaluate the severity of the test design modes, a comparative analysis was made of the demonstrated MTBFs of the generators of the three test design modes. The demonstrated MTBF values were 243.0, 139.5 and 137.4 hours for the Intensive Function, Simulated Tactical Use and Storage Modes, respectively. One-sided and two-sided 90-percent confidence interval estimates are presented in table 4. The MTBFs were tested for equivalence at a significance level of 0.05 using the statistical procedure described in TECOM Technical Report No. AD-A-2-78.[3] The results of the tests indicated that (a) the MTBF of the generators operated in the Intensive Function Mode was significantly different from those of the generators of the other two modes, and (b) the MTBF of the generators operated in the Simulated Tactical Use Mode was not significantly different from that of the generators of the Storage Mode.

Wilcoxon's rank sum test (a description is found in reference 4) for identical populations was chosen as the statistical test in the comparative analysis of the distributions of repair times of the generators operated in the three test design modes. The test was selected because it is especially sensitive to location differences between

[3] Hagan, John S., Comparing Two or More Mean Times Between Failures, US Army Test and Evaluation Command, Technical Note, Report No. ADA-2-78, September 1978.

[4] Hollander, Myles, and Douglas A. Wolfe, Nonparametric Statistical Methods, John Wiley and Sons, New York, 1973.

Table 4. Summary of Reliable Data

Test Mode	MTBF (hr)	Lower 90% Confidence Limit (hr)	90% Two-Sided Confidence Limits (hr, hr)
Intensive Function	243.0	195	185, 326
Storage	137.4	100	93, 212
Simulated Tactical Use	139.5	111	105, 190

the two compared populations and is likely to reject the null hypothesis of identical populations when the populations have unequal locations. The results of the tests indicated that only the distribution of the repair times of the generators operated in the Intensive Function Mode was different from those of the generators operated in the other two modes at a significance level of 0.05.

Because a nonparametric statistical test's verdict of nonidentical populations is tantamount to a verdict of unequal means, it is concluded that (a) the MTTR of the generators operated in the Intensive Function Mode was significantly different from those of the generators of the other two modes, and (b) the MTTR of the generators operated in the Simulated Tactical Use Mode was not significantly different from that of the generators of the Storage Mode.

2.2.3 Analyses of Individual Generator Component RAM Data by Test Mode

A more detailed examination of the generator failures and repair times was performed using table 5 which presents a summary of unscheduled maintenance actions. An inspection of table 5 reveals that for all test modes, 80 to 90 percent of all unscheduled maintenance actions involved similar types of component malfunctions. The distributions of the types of generator malfunctions which are shown in column 1 of table 5 were compared among the test design modes to determine if the observed proportions of the various types of malfunctions differed among the test modes. The comparative analysis employed the statistical test procedure given by paragraph 9.2 of AMC Pamphlet No. 706-111[5]. The results of the tests indicated that the distribution of the types of malfunctions did not differ among the three test modes at significance level of 0.05.

[5] US Army Materiel Development and Readiness Command, Engineering Design Handbook, Experimental Statistics (Section 2), AMC Pamphlet No. 706-111, 12 December 1969.

Table 5. Summary of Unscheduled Maintenance Actions

Repaired Component	INTENSIVE FUNCTION				STORAGE MODE				SIMULATED TACTICAL USE			
	Number of Actions[1]	Total Repair Time (hrs)	MTBF (hrs)	MTTR (hrs)	Number of Actions[1]	Total Repair Time (hrs)	MTBF (hrs)	MTTR (hrs)	Number of Actions[1]	Total Repair Time (hrs)	MTBF (hrs)	MTTR (hrs)
Carburetor	14	11.5	642	0.8	7	7.0	353	1.0	8	10.0	593	1.3
Voltage Regulator	5	3.0	1798	0.6	1	1.5	2472	1.5	5	4.5	948	0.9
Ignition	11	7.6	817	0.7	6	6.3	412	1.1	8	11.4	593	1.4
Fuse Breaker	3	0.4	2997	0.1	1	0.7	2472	0.7	2	1.0	2371	0.5
Valve	1	0.1	8990	0.1	-	-	-	-	2	2.5	2371	1.3
Freq Meter/Converter	-	-	-	-	-	-	-	-	3	2.5	1580	0.8
Rheostat	-	-	-	-	1	0.5	2472	0.5	2	1.7	2371	0.9
Miscellaneous	3	2.7	2997	0.9	2	5.6	1236	2.8	4	7.5	1185	1.9
TOTAL	37	25.3	243	0.7	18	21.6	137	1.2	34	41.1	139	1.2

[1]All unscheduled maintenance actions were chargeable failures.

Comparisons were made also of the MTBFs and MTTRs of the components listed in column 1 of table 5 to determine if the RAM characteristics of individual components differed among the test modes. The statistical test described by reference 3 was used to test equivalence of individual component MTBFs among the test modes and the Wilcoxon rank sum test was used to test the equivalence of the distributions of the generator repair times. A significance level of 0.05 was selected for both test procedures. No significant differences among the component MTBFs and MTTRs were evident.

The above results do not dismiss or contradict the results discussed earlier, namely that there are significant differences between the MTBF and MTTR of the generators of the Intensive Function Mode and those of the generators of the other two test modes. Rather, these results, when analyzed together with the earlier results, suggest that the differences between the generator MTBFs and MTTRs of these modes result from an apportioned effect which is not discernable when generator component RAM characteristics are statistically analyzed individually. Based on the results of the study, it appears that similar types of stresses were present in the three test design modes, but that the stresses which were present in the Intensive Function Mode were occurring at a lower level or, if the stresses are considered as random shocks, at a lower rate when compared to those of the other two test design modes.

As an example, let us assume that significant stresses are introduced by the act of starting a generator in the humid tropics and that these stresses eventually lead to or contribute to the occurrences of failures of one or several generator components. Because four times as many start-ups would be required in the Simulated Tactical Use Mode to achieve the same amount of operating time as in the Intensive Function Mode, the average stress level associated with start-ups would be four times higher in the Simulated Tactical Use Mode than in the Intensive Function Mode for the same amount of operating time. This higher average stress level would contribute, to a certain extent, to the occurrence of additional but similar types of failure over the same operating period, and thus a lower MTBF would result for generators operated in the Simulated Tactical Use Mode.

2.3.4 RAM Analysis of Tropic Storage Effects

After 6 months of humid tropic storage, the generators of the Storage Mode were examined for visible deterioration and returned to operational status. No meaningful deterioration of the generators was noted during the inspection. A statistical test (reference 3) comparing the failure data collected prior to storage with that collected after tropic storage showed that no significant (α = 0.05) degradation in performance had occurred.

Based on the above results, it is concluded that the 6-month tropic storage had no significant effect on the operation of the generators. The conclusion is supported, to a limited degree, by the similarity of the RAM data collected on the generators of the Simulated Tactical Use Mode and Storage Mode. No significant differences were found among the failure and maintenance data for the generators of these modes during the time frame of the study. These results would be expected if 6 months of tropic storage had no deteriorating effect on the generators. This is true because the two test modes had identical operational profiles (operation of 4 hours per workday), except for the 6-month period when the Storage Mode generators were placed into storage while the Simulated Tactical Use Mode generators continued to be operated at 4 hours per workday.

APPENDIX A. TEST DIRECTIVES AND METHODOLOGY INVESTIGATION PROPOSAL

(COPY)

DEPARTMENT OF THE ARMY
Headquarters, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

DRSTE-ME 24 June 1976

SUBJECT: Directive, Intensive Tropic Function Test
TRMS No. 7-CO-RDT-TT1-001

Commander
US Army Tropic Test Center
ATTN: STETC-AD-MI
APO NY 09827

1. Reference is made to TECOM Regulation 70-12, dated 1 June 1973.

2. This letter and attached STE Forms 1188 and 1189 (Incl 1) constitute a directive for the subject investigation under the TECOM Methodology Improvement Program 1U765702D625.

3. The information at Inclosure 2 and the attached guidance at Inclosure 3 are the basis for headquarters approval of the subject investigation.

4. Special Instructions:

a. All reporting will be in consonance with paragraph 9 of the reference. The final report, when applicable will be submitted to this headquarters, ATTN: DRSTE-ME, in consonance with Test Event 52, STE Form 1189.

b. Recommendations of new TOPs or revisions to existing TOPs will be included as part of the recommendation section of the final report. Final decision on the scope of the TOP effort will be made by this headquarters as part of the report approval process.

c. The utilization of the funds provided to support the final investigation is governed by the rules of incremental funding.

d. The addressee will determine whether any classified information is involved and will assure that proper security measures are taken when appropriate.

DRSTE-ME 24 June 1976
SUBJECT: Directive, Intensive Tropic Function Test
TRMS No. 7-CO-RDT-TT1-001

e. Under the new approved management concept for the methodology program, responsibilities will be delegated as follows:

(1) The Methodology Improvement Directorate will be responsible for management of the methodology programs to include: administration, funding, development, justification and documentation of the programs, and all coordination not specifically designated to other organizations and/or individuals.

(2) The headquarters technical responsibilities, which include planning, executing and controlling of specific methodology investigations, will be assigned to the most qualified individuals within TECOM using the technical sponsor concept. Although the technical sponsor concept has been approved, the details of implementation have not been finalized as yet. You will be provided with the implementation plan when it becomes available.

f. The Methodology Directorate point of contact and the technical sponsor is Mr. Joseph E. Steedman, ATTN: DRSTE-ME, Autovon 283-2375/2170.

FOR THE COMMANDER:

3 Incl
as

/s/Frances T. Smith
/t/FRANCES T. SMITH
Admin Asst, SGS

(END COPY)

(COPY)

DEPARTMENT OF THE ARMY
Headquarters, U.S. Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland 21005

DRSTE-ME 4 Nov 1976

SUBJECT: Directive, Intensive Tropic Function Test, TRMS No. 7-CO-RDT-TT1-001

Commander
US Army Tropic Test Center
ATTN: STETC-TD-O
Fort Clayton, Canal Zone

1. Reference is made to:

a. Letter, DRSTE-ME, 24 June 1976, subject as above.

b. Letter, STETC-TD-M to DRSTE-ME dated 14 September 1976, subject: Methodology Program Funding.

c. Letter, STETC-TD-M to DRSTE-DA dated 7 October 1976, subject: Methodology Investigation - Intensive Tropic Function Test, TRMS No. 7-CO-RDT-TT1-001.

d. Letter, DRSTE-ME DATED 29 October 1976, subject: Procedure for Costing Methodology Funds.

2. This letter and attached STE Form 1189 (Inclosure 1) constitute a directive for continuation of the subject investigation.

3. The information at Inclosure 2 and the guidance at Inclosure 3 are the bases for headquarters continuation of the investigation.

4. Special Instructions:

a. Special instructions of paragraphs 4a, b, c, d, and e(1) of reference 1a are still in effect.

DRSTE-ME 4 Nov 1976
SUBJECT: Directive, Intensive Tropic Function Test,
TRMS No. 7-CO-RDT-TT1-001

b. The TECOM point of contact and technical sponsor is Mr. Sidney Wise, ATTN: DRSTE-ME, AUTOVON 283-2170/3677.

FOR THE COMMANDER:

3 Incl
as

/s/ Sidney Wise
/t/ SIDNEY WISE
Director, Methodology
Improvement

(END COPY)

(COPY)

Revised
March 1976

1. TITLE. Intensive Tropic Function Tests

2. CATEGORY. Environmental Testing

3. INSTALLATION. US Army Tropic Test Center
PO Drawer 942
Ft Clayton, CZ
(APO New York 09827)

4. PRINCIPAL INVESTIGATOR. E. M. Cady
Technical Division
STETC-TD
313-285-4256

5. STATEMENT OF THE PROBLEM. In keeping with current DODIs and ARs, the materiel acquisition process must be shortened without sacrificing quality. Project managers and AMC commodity commands many times curtail or forego tropic DTII because of time/cost considerations. By compressing the test, quicker and more valid results might be obtained for many hardware systems. However, the storage phases of tropic tests have surfaced many test item failures over the years. These failures are sometimes catastrophic, as was the recent case with the Forward Area Alerting Radar System. A requirement therefore exists to determine whether intensified function tests can substitute or only supplement tropic tests with a storage phase.

6. BACKGROUND. Personnel from TECOM materiel test directorates have expressed interest in reducing test time by intensifying functioning of test items and obtaining a greater volume of RAM data. To do so within a fixed time frame would reduce the duration of the tropic storage phases. The purpose of the present investigation is to determine whether intensified tropic function tests yield data which are more or less useful than, or complementary to, storage tests. A prior year related investigation was "Reliability and Maintainability of Materiel Items in the Tropics," TECOM Project No. 9 CO 019 000 001. This investigation was concerned with a RAM study of equipment under bona fide use in operational TO&E units in the Canal Zone. No data on intensive functioning were available.

7. GOAL.

a. The investigation will lead to a tropic test methodology for intensified testing.

b. The investigation will reassess the tropic DTII design sequence of storage testing.

8. DESCRIPTION OF INVESTIGATION.

a. The Tropic Test Center is investigating intensive functioning tests by testing three samples of generator sets under three test designs. The designs are: (1) Intensified function testing for 16 hours per day, (2) testing through 4 hours on, 20 hours off, cycles, and (3) testing as in (2) for the first 50 hours followed by 6 months storage followed by function testing as in (2). RAM and performance data collected will be analyzed to determine usefulness and test design validity.

b. TTC is conducting the investigation at an established test site, using the above test designs. Generators, 1.5KW, FSN 6115-889-1446, are being used. Generators lend themselves exceptionally well to this investigation because they can be functioned continously with a minimum of manpower and provide a good volume of RAM data for analysis. System performance characteristics will be compared between the three designs to determine severity of each. AR 705-50 and the TECOM supplement will be used to conduct reliability analysis.

9. PROGRESS. Function tests started on 1 March 1976, upon receipt of 15 generators from TROSCOM on loan. Procurement and site preparation accomplished included the following:

-Design and fabrication of fuel distribution system

-Design and construction of firewalls, safety and security devices

-Design, fabrication, and installation of electrical load banks, wiring, and master instrument console

-Receipt inspection and check-out of all generator sets

10. JUSTIFICATION.

a. Due to delays in procurement of materials and supplies and availability of the generator sets, the investigation did not start operations until third quarter, FY76. Therefore, the investigation schedule has been revised to include completion during third quarter, FY77. Many resources would be wasted if it were not allowed to continue into FY77.

b. Dollar Savings. None

c. Workload. No generator sets have been tested by the center in the past. Several turbine generator tests are anticipated in the future. Prototypes ranging from 5KW to 100KW are under development.

Anticipated future workload is 9 tests. Examples of items, to include other types of electromechanical systems, anticipated for testing are:

FY	77	78	79	80
1.5KW Silent Power Source				ST(DTII)
10KW Turbine Generator Set		ST(DTII)		
30KW Turbine Generator Set		ST(DTII)		
Radar, Mortar Tracking	ST(DTII)			
FAMECE		(DTII)		
Ground-Based ESM	ST(DTII)			
Armored Reconnaissance Scout Vehicle (XM800)	PV			
Sealed Beam Integrated Reflector Searchlight (SBIR)	ST(DTII)	ST(DTII)		
Modular Collective Protection Equipment	ES(DTII)			

d. Recommended TRMS Priority. 2

e. Association with Requirements Documents.

(1) Related materiel need documents covering electric/electronics equipment are:

(a) Ground Surveillance Radar (QMDO)

(b) Tactical Radio Communications System

(c) Air Traffic Control Facility (ATCF)

Some of this equipment is supported by generator sets. Since all tests involve electrical or electronic components, the subject investigation will prove highly beneficial.

(2) The QMR entitled "Military Design Family of Electric Power Plants (5KW-100KW)" indicates a one-for-one replacement of Gasoline Engine Drive (GED), Turbine Engine Drive (TED), and Diesel Engine Drive (DED) sets in the Army inventory. This QMR includes stringent reliability and maintainabililty criteria. For example, the required Mean Time Between Overhaul is 6,000 hours, Inherent Availability is 97%, and Mean Time Between Failure is 470 hours. A proposed QMR for

a family of Silent Lightweight Energy Plants (SLEEP) deals with generator sets in the 0.5 through 15.0KW sizes.

f. Other. The investigation is being conducted to provide a non-existent tropic test capabililty, i.e., a methodology for an intensified functioning tropic test. The subject investigation will also provide the background information and instrumentation necessary to conduct future turbine generator tests and related families of equipment.

11. RESOURCES.

a. Financial.

(1) Funding Breakdown.

	Dollars (Thousands) FY77	
	In-House	Out-of-House
Personnel Compensation	12.0	
Travel		11.5
Contractual Support		
Consultants & Other Services		
Materials & Supplies	2.0	
Equipment		
G&A Costs	18.9	
Subtotals	32.9	11.5
FY Total	44.4	

(2) Explanation of Cost Categories.

(a) Personnel Compensation. N/A

(b) Travel. N/A

(c) Contractual Support. Contractor support is required to provide scheduled and operator maintenance and to assist in data collection.

(d) Consultants & Other Services. N/A.

(e) Materials & Supplies. Replacement parts for generators.

(f) Equipment. Six turbine generator sets (PEMA items).

(g) G&A Costs. G&A costs are computed at the rate of $18 per direct labor man-hour. This rate, provided by the TTC Budget Office, includes overhead costs and host-tenant agreement support cost.

b. Anticipated Delays. None

c. Obligation Plan.

FQ	7T	1	2	3	Total
Obligation Rate (Thousands)	22.5	11.0	10.9	0	44.4

d. In-House Personnel.

(1)

			FY7T & FY 77		
			Man-Hours		Study Hours
		Number	Rqrd	Avail	Rqrd
Matls Engr	GS-0806	1	500	500	
Opns Rsch Anal	GS-1515	1	350	350	
Gen Engr	GS-0801	1	100	100	
Elec Engr	GS-0855	1	100	100	
			1050	1050	550

(2) Resolution of Nonavailable Personnel. N/A

(3) Study Hours. Anticipated study hours are 550.

12. INVESTIGATION SCHEDULE.

	FY7T	FY77
	J A S	O N D J F M A M J
In-House	- - -	- - - - - - - R
Contract	- - -	- - - -

13. ASSOCIATION WITH TOP PROGRAM. TOP 1-1-008, Materiel Testing in the Tropics, will be revised as a result of this investigation.

/s/ Matthew B. Lamer, Jr.
/t/ MATTHEW B. LAMER, JR.
LTC, FA
Acting Commander

(END COPY)

APPENDIX B. REFERENCES

1. AR 1000-1, Basic Policy for Systems Acquisition, 1 April 1978.

2. DA Technical Manual TM-5-6115-323-15, Generator Set, Gasoline Engine Driven, Skid Mounted, Tubular Frame, 1.5 KW, Single Phase, AC, 120/240V, 9 September 1970.

3. Hagan, John S., Comparing Two or More Mean Times Between Failures, US Army Test and Evaluation Command, Technical Note, Report No. AD-A-2-78, September 1978.

4. Hollander, Myles and Douglas A. Wolfe, Nonparametric Statistical Methods, John Wiley and Sons, New York, 1973.

5. US Army Materiel Devleopment and Readiness Command, Engineering Design Handbook, Experimental Statistics (SEC 2), AMC Pamphlet No. 706-111, 12 December 1969.

APPENDIX C. DISTRIBUTION LIST

TECOM PROJECT NO. 7-CO-RDT-TTI-001
Intensive Tropic Function Testing

Addressee	Final Report
Commander US Army Test and Evaluation Command ATTN: DRSTE-ME DRSTE-AD Aberdeen Proving Ground, MD 21005	 3 1
Commander US Army Materiel Development and Readiness Command ATTN: DRCDMD-ST DRCDE 5001 Eisenhower Avenue Alexandria, VA 22333	 1 3
HQDA (DAMA) Washington, DC 20310	1
Director The Army Library The Pentagon, Rm 1A526 Washington, DC 20310	 2
Director Naval Research Library ATTN: Code 2627 Washington, DC 20375	 1
Assistant Secretary of Army (RDA) ATTN: Assistant for Science and Technology Washington, DC 20310	 1
Commander US Army Aircraft Development Test Activity ATTN: Tech Director Fort Rucker, AL 36362	 1
Environmental Information Division Bldg 754 Maxwell Air Force Base, AL 36112	 2

Addressee	Final Report
Commander US Army Missile Materiel Readiness Command Redstone Arsenal, AL 35809	 1
Commander US Army Missile R&D Command Redstone Arsenal, AL 35809	 1
Commander US Army Electronic Proving Ground ATTN: STEEP-MT-I Fort Huachuca, AZ 85613	 1
Commander US Army Yuma Proving Ground ATTN: STEYP-MMI STEYP-MTD (Tech Lib) STEYP-MTS (Lab Sup) Yuma, AZ 85364	 1 1 1
Director Naval Weapons Center ATTN: Code 4530 China Lake, CA 93555	 1
Commander Environmental Prediction Research Facility Naval Postgraduate School Monterrey, CA 93940	 1
President US Army Infantry Board ATTN: Tech Director Fort Benning, GA 31905	 1

Addressee	Final Report
Commander US Army Armament Materiel Readiness Command ATTN: DRSAR-RDM Rock Island, IL 61299	1
Commander US Army Natick R&D Command ATTN: DRDNA Natick, MA 01762	1
Director US Army Materials and Mechanics Research Center ATTN: DRXMR-CT Watertown, MA 02172	1
Commander US Army Aberdeen Proving Ground ATTN: STEAP-MTD Aberdeen Proving Ground, MD 21005	1
Director US Army Ballistics Research Laboratory ATTN: DRXMR-CT Bldg 305 Aberdeen Proving Ground, MD 21005	1
Director US Army Materiel Systems Analysis Activity ATTN: DRSXY-MP Aberdeen Proving Ground, MD 21005	2
Commander US Army Chemical Systems Laboratory ATTN: DRDAR-CLJ Aberdeen Proving Ground, MD 21010	1
Commander US Army Tank Automotive R&D Command Warren, MI 48090	1
Commander US Army Electronics R&D Command ATTN: DRXDO-DAC 2800 Powder Mill Road Adelphi, MD 20783	1
Commander US Army Troop Support and Aviation Materiel Readiness Command 4300 Goodfellow Blvd St. Louis, MO 63120	1
Director US Army Waterways Experiment Station ATTN: Tech Lib Vicksburg, MS 39180	1
Commander US Army Armament R&D Command ATTN: DRDAR-TD Dover, NJ 07801	1
Commander US Army Communications R&D Command Fort Monmouth, NJ 07703	2
Commander US Air Force Test and Evaluation Center ATTN: AFTEC/XR Kirtland Air Force Base, NM 87115	1
Commander US Army White Sands Missile Range ATTN: STEWS-TE White Sands, NM 88002	1
Director US Army Atmospheric Sciences Lab US Army Electronics R&D Command White Sands, NM 88002	1

Addressee	Final Report	Addressee	Final Report
Commander US Army Cold Regions Test Center APO Seattle 98733	1	Commander US Army Tropic Test Center ATTN: STETC-MTD-TB STETC-MTD-AB STETC-MTD-AB (TIC) STETC-MTD-AB (Tech Ed) APO Miami 34004	 10 6 30 2
Commander US Army Dugway Proving Ground ATTN: STEDP-SC STEDP-MT Dugway, UT 84022	 1 1		
Commander US Army Operational Test and Evaluation Agency ATTN: DACS-TEO-N 5600 Columbia Pike Falls Church, VA 22041	2		
Officer-in-Charge Naval Surface Weapons Center Dahlgren Laboratory ATTN: DX-21 Dahlgren, VA 22448	1		
Administrator Defense Technical Information Center ATTN: DDC-T Cameron Station, Alexandria, VA 22314	2		
Director US Army Engineer Topographic Labs ATTN: ETL-GSL Fort Belvoir, VA 22060	3		
Commander US Army Mobility Equipment R&D Command ATTN: DRDME-NS Fort Belvoir, VA 22060	1		
Commander-in-Chief US Southern Command ATTN: SCJ-3 APO Miami 34003	1		
Commander 193d Infantry Brigade (Panama) APO Miami 34007	1		